

阳泉矿区煤层气项目招商报告

# Investment Opportunities in Coal Mine Methane Projects in Yangquan Mining Area



United States Environmental Protection Agency



China Coalbed Methane Clearinghouse

October 2001 Beijing



Chairman: Wang Yinong



President: Wang Tixuan

Dear Colleague,

Situated in the east of Shanxi province, Yangquan Coal Group Co., Ltd.(YCG), a state owned enterprise, is reformulated from Yangquan Coal Mining Administration, which is founded in 1950.

After 50 years development, YCG has developed into one of the super-large state owned enterprises affirmed in the first batch, being one of the 520 largest industrial enterprises in China. It is the largest anthracite production base in China. The company has been in profit for continuous 8 years, and the selling income in 2000 is 5.7 billion yuan, with fixed assets 8.47 billion yuan. It is granted with "AAA" grade in credibility with the bank.

With a total area of 1414 km<sup>2</sup>, coal reserves of 14.1 billion ton, there are 11 shafts in 6 active coal mines. The total designed capacity is 16 million ton/year. In recent years, the actual output is about 15 million ton. According to the enterprise development plan, coal output will be stable and increase gradually to 22.5 million ton in 2015.

There are rich coalbed methane resources in Yangquan mining area. It is estimated that the gas content is 5-30 m<sup>3</sup>/t and the total coalbed methane resources is 687.4 billion m<sup>3</sup> within 3020 km<sup>2</sup> to a depth of 1500m below surface. For ensuring mining safety, 11 shafts are all equipped with CMM drainage systems, there are 8 CMM drainage stations, 5 storage facilities with total capacity of 110,000 m<sup>3</sup>. In recent years, the methane recovered is about 120 million m<sup>3</sup>, and only 40 million m<sup>3</sup> is utilized in the Yangquan City. In

favorable area in Yangquan mining area, the coal seam is deposited at appropriate depth, with rich gas content, and coal seam permeability is around 1 md. This area is about 60 km from Taiyuan, the capital city of Shanxi province, with urban population of more than 2.0 million. There has huge and urgent clean energy demand, therefore, there is bright commercial development prospect of the coalbed methane resources development project.

With the development strategy of coal as the basic business and diversified economy sharing equal importance, coalbed methane development and utilization has become one of the four important sectors. The recent CBM/CMM projects are the Shouyang CBM surface development project, the extension of CMM recovery project, the CMM power generation project. With good CMM/CBM resources and market conditions, there is bright development prospect. Investors from all over the world are welcome to be here for project investigation and discussion, for further cooperation with YCG on the projects of CMM/CBM development and utilization.

Sincerely,

Wang Yinong  
Chairman of Yangquan Coal Group Co., Ltd.

## Executive Summary

### Background

Yangquan Coal Group Co., Ltd. (YCG) is one of the super-large state owned enterprises affirmed in the first batch, one of the 520 largest industrial enterprises in China. It is the largest anthracite production base in China with annual coal production capacity of 16 million ton. According to the YCG development scheme, the output will be stable and increased gradually in the future 15 years, it will reach 22.5 million ton by 2015.

There are abundant coal resources and coalbed methane resources, and the coal resources



are 14.1 billion ton, while the coalbed methane resources 687.4 billion m<sup>3</sup>. The 11 shafts in 6 production mines are all gassy shafts while the average gas content of main mineable coal seams is 17.2 m<sup>3</sup>/t. The annual methane emission in Yangquan mining area is over 4 billion m<sup>3</sup> in recent years. With the more coal produced and deeper seam mined, the methane emission will increase year by year. At present, there are 8 methane drainage stations in operation, and 120 million m<sup>3</sup> methane recovered annually. With more input, the methane will recover more and more.

### **Investment Opportunities**

At present, the annual utilized methane is about 40 million m<sup>3</sup> in YCG, which is only about one-third of the recovered methane. Based upon this, for fully utilizing the excess methane, YCG proposed a methanol plant and a power plant fueled with CMM, of which the CBM power plant is to be built by using foreign capitals. YCG underground CMM recovery is mainly to solve the mine safety, so the recovery rate is low. The extension of CMM drainage can not only increase the recovered CMM, but also increase the coal productivity. It has the characteristic of less investment, fast step and better effect. Therefore, YCG planned to take CMM comprehensive development as a sector.

Besides, there is opportunity in Shouyang block of Yangquan mining area. In this block, the coal seam is deposit appropriate shallow, with rich gas content, and the resource density is 151 million m<sup>3</sup>/km<sup>2</sup>. With developed cleat and fracture, the permeability of reservoirs is medium. While the adjacent cities have huge demand on clean energy. So, YCG proposed the CBM surface development project in this block, which is hopefully supply CBM to Taiyuan City. Following is a summary of these three potential CMM/CBM development and utilization projects, for which YCG is seeking investment.

- 1) *CBM surface development project.* This project will use vertical well method recover coalbed methane in Shouyang block. The project includes the construction of 184 surface wells, and the coalbed methane recovered will be supplied to Taiyuan City. The annual gas production is 200 million m<sup>3</sup>. The service life of the project is 20 years. Total cost of the project is estimated at about 700 million yuan (US\$ 84.34 million), among which, exploration cost 4.38 million yuan (US\$ 528,000) will be provided by foreign company in the form of venture exploration, other investment source and proportion are to be determined by discussion. Based on the total investment, the estimated NPV of the project would be 120 million yuan (US\$14.46 million), the IRR would be 18%, and the payback time would be 12 years. YCG proposes to start the project in early 2004 and fully complete in 2009.
- 2) *Extension of underground CMM Recovery project.* The project is to take underground CMM development as a sector. The production scale of the project is 60 million m<sup>3</sup>/a and all the gas production will be provide to Yangquan City using as town gas. The service life of the project is 20 years. Total cost of the project is estimated at 90 million yuan (US\$ 10.84 million), among which, YCG would provide 35%, and is seeking the remaining 65% (US\$ 7.05 million) from outside investment and fund sources. Based on the total investment, the estimated NPV of the project would be 32 million yuan (US\$ 3.86 million), the IRR would be 12%, and the payback time would be 10 years. When the project will be

started depend on the availability of the capitals.

- 3) *CMM power plant project*. It is proposed that a CMM power plant set up in Xinjing Coal mine, the capacity of which is 11 MW, with annual  $73.26 \times 10^6$  kWh power supplied. Total cost of the project is estimated at 64.6 million yuan (US\$ 7.78 million), among which, YCG would provide 35%, and is seeking the remaining 65%(US\$ 5.06 million) from outside investment and fund sources. Based on the total investment, the estimated NPV of the project would be 14.95 million yuan (US\$ 1.8 million), the IRR would be 23%, and the payback time would be 7 years. YCG proposes to start the project in 2002 and fully complete in 2003.

The YCG recognizes that investment in these projects may have certain risks. The variations in CMM/CBM price and production, and the applicability of technology may affect project economics. The YCG is ready to help determine market risk for potential foreign investors and is willing to answer any important questions investors may have.

YCG is also ready to consider every possible way of cooperation and various means for raising capital to carry out the above projects. Representatives of banks, foreign companies and overseas financial organizations are welcome to review the attached marketing package and contact us for more information:

Mr. Li Baoyu  
Chief Engineer  
Yanguqan Coal Group Co. Ltd.  
Yangquan City  
Shanxi 045000, China  
Tel/Fax: 0086-353-7070897  
Email: ycgcbm@public.yq.sx.cn

## 1. Overview

Situated in the East-central of Shanxi province, north part of Qinshui coal field, Yangquan mining area is consisted of production block, Shouyang block, Pinxi block and Hezuo block. The total area cover 3020 km<sup>2</sup>, containing an estimated 13.2 billion ton of coal reserves. Most of the coal reserves in the mining area are anthracite, with high coalbed methane generation, storage capacity and rich methane content. It is estimated that the total coalbed methane resources are about 687.4 billion m<sup>3</sup> within the 3020 km<sup>2</sup> area to a depth of 1500m. Although located in the mountainous area, the mining area enjoys very convenient transport facilities in that both highways and railroads running in all directions (Fig.1).

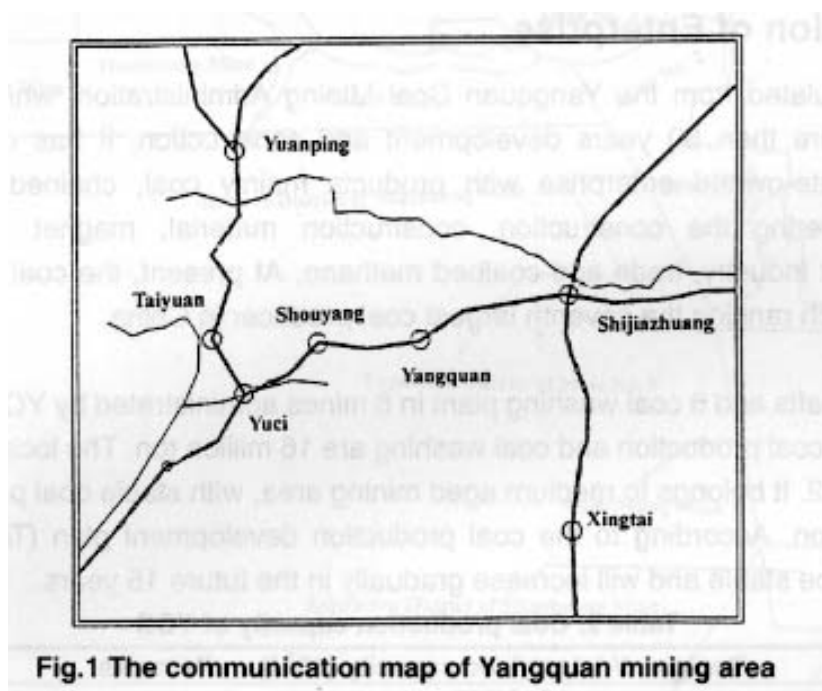


Fig.1 The communication map of Yangquan mining area

For ensuring the coal mine safety, there set 8 methane drainage stations in 6 active mines. The annual recovered CMM approximately reached 120 million m<sup>3</sup>, of which only about 40 million m<sup>3</sup> was utilized in the Yangquan city gas system. Due to the shortage of utilization facilities, the CMM drainage is maintained at a low level, even though there is about two-third of the CMM drainage vented to atmosphere.

Based upon the CMM recovery potential and the market situation, Yangquan Coal Group Co. Ltd. (YCG) planned to set up the projects of the CBM Surface Development, the Extension of Underground CMM Recovery and the CMM Power Generation.

The CBM surface development project is based upon the CBM resources locally, and it will supply the CBM to adjacent cities, to reach an aim of fully utilizing CBM resources. The project can supply CBM 200 million m<sup>3</sup> annually with service life of 20 years.

The extension of underground CMM recovery project takes the CMM as a sector. The project will provide CMM to Yangquan City using as town gas. The project will supply CMM 60 million m<sup>3</sup> annually with service life of 20 years.

The power generation project is based the exist methane drained from coal mine No.3 and Xinjing mine, and without further infrastructure investment, there set up a power plant with

capacity of 11 MW. The project will serve the mining area to make profit.

The above mentioned three projects are to be organized and implemented by YCG as a commercial project. Results of a preliminary financial analysis are shown in Table 1.

**Table 1. Results of the financial analysis for Yangquan mining area CMM/CBM projects**

Projects	Fixed investment (million yuan)	Production cost (million yuan/a)	Sale income (million yuan/a)	IRR (%)	Pt (year)
CBM surface development	694.68	93.47	240.0	18	12
Extension of CMM recovery	90.0	18.0	36.0	12	10
Power generation	64.60	15.84	20.51	23	7

## 2. Introduction of Enterprise

YCG is reformulated from the Yangquan Coal Mining Administration, which is founded in 1950. After more than 50 years development and construction, it has developed into a super-large state-owned enterprise with products mainly coal, chained by coal-power-aluminum, covering the construction, construction material, magnet material, mining machinery, light industry, trade and coalbed methane. At present, the coal production is 14 million ton, which ranking the seventh largest coal producer in China.

There are 11 shafts and 6 coal washing plant in 6 mines administrated by YCG. The designed capacity of raw coal production and coal washing are 16 million ton. The location of the mines is shown in Fig.2. It belongs to medium aged mining area, with stable coal production around 14~16 million ton. According to the coal production development plan (Table 3), the coal production will be stable and will increase gradually in the future 15 years.

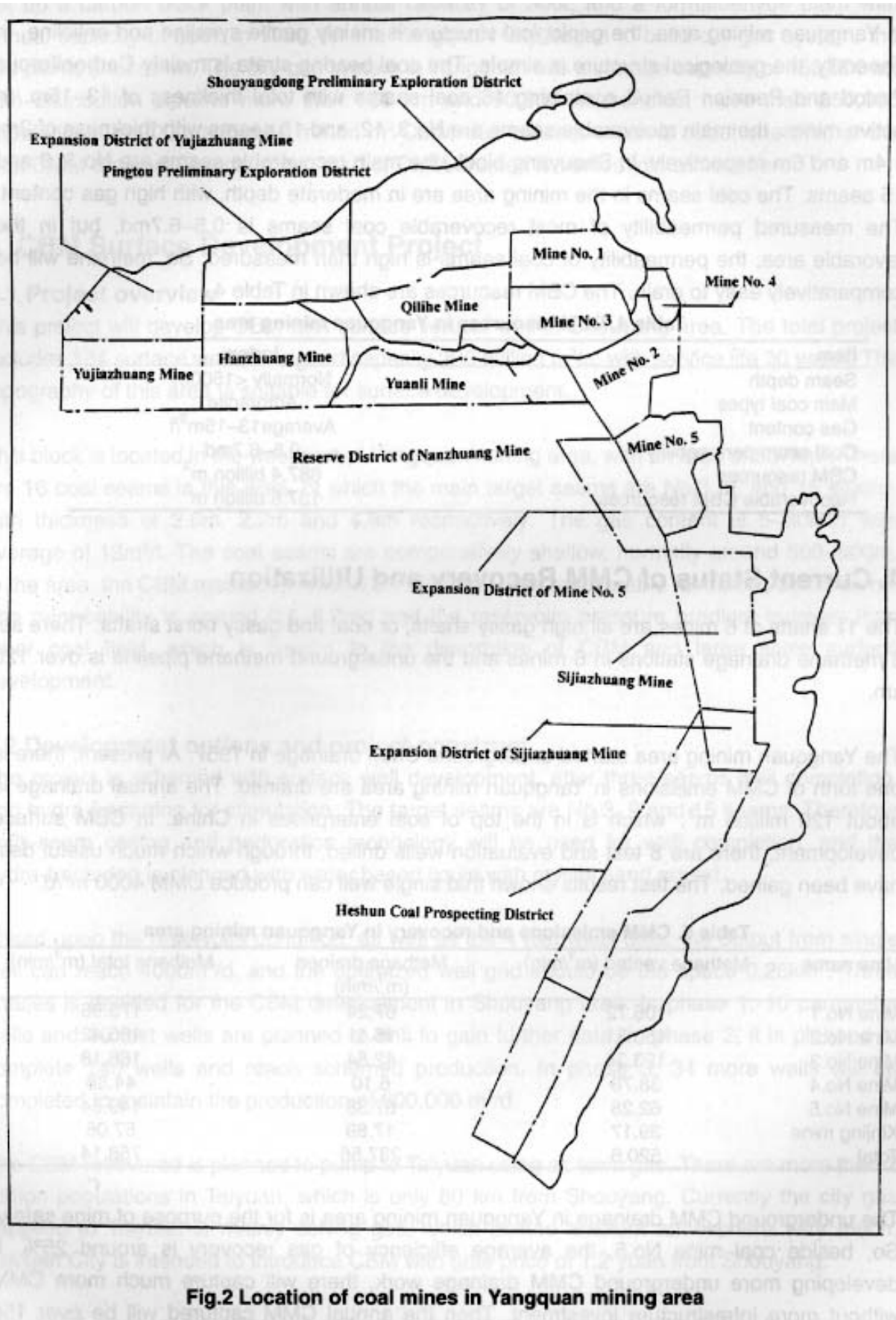
**Table 2. Coal production capacity of YCG**

Mine name	Designed/determined capacity (10 <sup>3</sup> t)	Remarks
Mine No.1	240/350	
Mine No.2	435/400	
Mine No.3	250/300	
Mine No.4	90/110	will be abandoned in 2004
Mine No.5	400/150	
Xinjing mine	200/200	put into operation in 1999
Total	1615/1510	

YCG is among the largest 520 enterprises in China, and has been profitable since the government didn't restricted coal price in 1993. In recent years, affected by the weakened coal market, the enterprise profit decreased to some extent. But, there is less impact on the total economy of the enterprise. In 2000, the coal production is 13.37 million ton, with total income of 5.7 billion yuan and fixed assets of 8.47 billion yuan. It is qualified as a "AAA" of grade enterprise in band qualification and credit. At present, part of the high quality assets of YCG is planned to go to stock exchange, and hopeful to be on stock market in early 2002.

**Table 3. Coal production plan of YCG in future 15 years**

Year	Schemed coal production (Mt)
2001	15.00
2002~2005	16.50
2006~2007	19.50
2008~2010	22.50
2011~2015	22.50



**Fig.2 Location of coal mines in Yangquan mining area**

### 3. Coalbed Methane Resources

In Yangquan mining area, the geological structure is mainly gentle syncline and anticline. In generally, the geological structure is simple. The coal bearing strata is mainly Carboniferous Period and Permian Period containing 16 coal seams with total thickness of 13~15m. In active mines, the main recoverable seams are No.3, 12, and 15 seams with thickness of 2m, 1.4m and 6m respectively. In Shouyang block, the main recoverable seams are No.3, 9 and 15 seams. The coal seams in the mining area are in moderate depth, with high gas content. The measured permeability of most recoverable coal seams is 0.5~6.7md, but in the favorable area, the permeability of coal seams is high than measured. So, methane will be comparatively easy to drain. The CBM resources are shown in Table 4.

**Table 4. CBM resources in Yangquan mining area**

Item	Index
Seam depth	Normally <1500m
Main coal types	Anthracite
Gas content	Average 13~15m <sup>3</sup> /t
Coal seam permeability	0.5~6.7md
CBM resources	687.4 billion m <sup>3</sup>
Recoverable CBM resources	137.5 billion m <sup>3</sup>

### 4. Current Statue of CMM Recovery and Utilization

The 11 shafts of 6 mines are all high gassy shafts, or coal and gassy burst shafts. There set 8 methane drainage stations in 6 mines and the underground methane pipeline is over 120 km.

The Yangquan mining area started underground CMM drainage in 1957. At present, there is one forth of CMM emissions in Yangquan mining area are drained. The annual drainage is about 120 million m<sup>3</sup>, which is in the top of coal enterprises in China. In CBM surface development, there are 8 test and evaluation wells drilled, through which much useful data have been gained. The test results shown that single well can produce CMM 4000 m<sup>3</sup>/d.

**Table 5. CMM emissions and recovery in Yangquan mining area**

Mine name	Methane vented (m <sup>3</sup> /min)	Methane drained (m <sup>3</sup> /min)	Methane total (m <sup>3</sup> /min)
Mine No.1	106.72	67.24	173.96
Mine No.2	150.31	16.11	166.42
Mine No.3	123.34	42.84	166.18
Mine No.4	38.78	6.10	44.88
Mine No.5	62.28	87.38	149.64
Xinjing mine	39.17	17.89	57.06
Total	520.6	237.56	758.14

The underground CMM drainage in Yangquan mining area is for the purpose of mine safety. So, beside coal mine No.5, the average efficiency of gas recovery is around 25%. If developing more underground CMM drainage work, there will capture much more CMM without more infrastructure investment. Then the annual CMM captured will be over 150 million m<sup>3</sup>.

The CMM utilization in Yangquan mining area is started in 1958, and the large-scale utilization is in 1970s, when the connected methane utilization systems were set up in coal



mines No.1, 2 and 3. At that time, more than 5000 households use CMM as fuel. There also set up a carbon black plant with annual capacity of 300t, and a formaldehyde plant with annual capacity of 500t. In 1980, for the Yangquan City began to build city-gas system, the two plants shut down. The city-gas system in Yangquan has a storage capacity of 160,000 m<sup>3</sup>, with distribution pipeline more than 160 km and 90,000 households, more than 250,000 populations. In 2000, about 40 million m<sup>3</sup> CMM was utilized, which is about one third of the total CMM drained. The other two third of CMM drained is vented into atmosphere.

## **5. CBM Surface Development Project**

### **5.1 Project overview**

This project will develop CBM with surface vertical well in Shouyang area. The total project includes 184 surface wells, designed capacity 200 million m<sup>3</sup>/a, with service life 30 years. The topography of this area is suitable for surface development.

This block is located in the west part of Yangquan mining area, with an area of 557km<sup>2</sup>. There are 16 coal seams in this area, of which the main target seams are No.3, 9, and 15 seams, with thickness of 2.6m, 2.2m and 4.8m respectively. The gas content is 5~30m<sup>3</sup>/t with average of 13m<sup>3</sup>/t. The coal seams are comparatively shallow, normally around 500~800m. In the area, the CBM resources reach 78.8 billion m<sup>3</sup>, and recoverable resources 35 billion m<sup>3</sup>. The permeability is around 0.5~6.7md and the reservoirs pressure gradient is lower than other coal field, which is helpful to the desorption of CBM and large scale surface development.

### **5.2 Development options and project construct**

The project is schemed with surface well development, after three seams well completion, and hydra-fracturing for stimulation. The target seams are No.3, 9 and 15 seams. Therefore multi-seam casing and perforation technology will be used for well completion, and the hydra-fracturing is planned with water based liquid with crystal sand added.

Based upon the reservoirs condition, as well as the 4 test wells data, the output from single well can reach 4000m<sup>3</sup>/d, and the optimized well grid should be the space 0.25km<sup>2</sup>. Three phases is decided for the CBM development in Shouyang area. In phase 1, 10 parameter wells and 10 test wells are planned to drill to gain further data. In phase 2, it is planned to complete 140 wells and reach schemed production. In phase 3, 34 more wells will be completed to maintain the production of 600,000 m<sup>3</sup>/d.

The CBM recovered is planned to pump to Taiyuan using as town gas. There are more than 2 million populations in Taiyuan, which is only 60 km from Shouyang. Currently the city gas supplied to Taiyuan is mainly coking gas, which pollute ambient atmosphere very much. Taiyuan City is intended to introduce CBM with gate price of 1.2 yuan from Shouyang.

The CBM surface development project is schemed to initiate from 2003, the designed capacity of which is 200 million m<sup>3</sup>/a, with service life over 20 years. The major technical and economic index of the CBM surface development project is shown in Table 6.

**Table 6. Major technical and economic index of the CBM surface development project**

Item	Index
Total investment	694.68 million yuan
Production capacity	200 million m <sup>3</sup> /a
Number of production wells	184
Investment per well	3.12 million yuan
Well spacing	0.25 km <sup>2</sup>
Single well production	4000 m <sup>3</sup> /d

### 5.3 Financial analysis

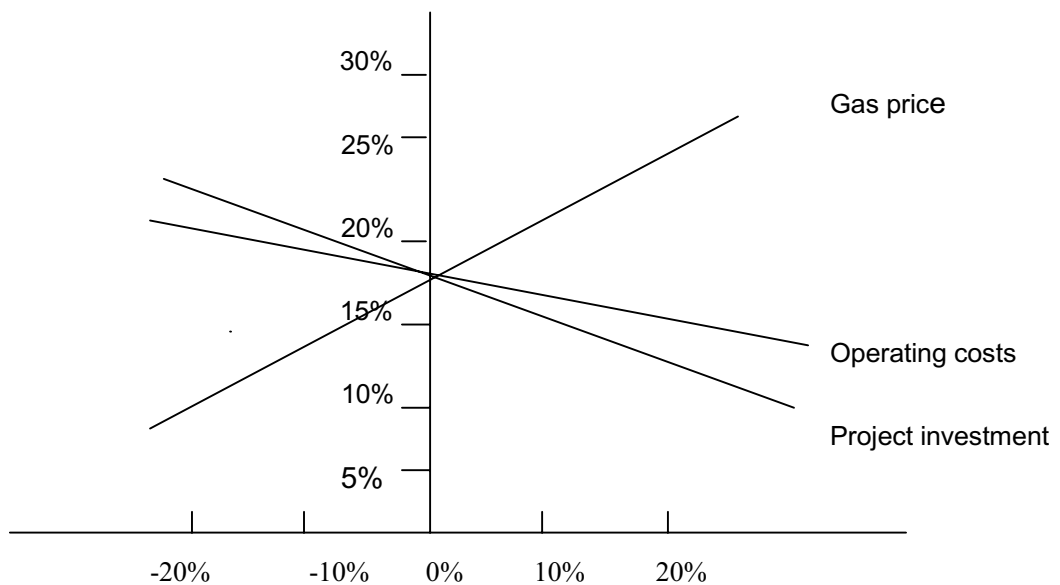
The project total investment is 694.68 million yuan. The enterprise plans to raise 65% of the total investment of the project from banks, foreign companies and overseas financial organizations. The other 35% will be solved by YCG as equity.

The single well annual depreciation is 208,000 yuan and the operating cost is 300,000 yuan. In stable production period, the production is 200 million m<sup>3</sup>/a, therefore the CBM production cost is roughly 0.47 yuan / m<sup>3</sup>.

The discounted cash flow method is used to analyze the profitability of the CBM project. Assuming a real discount rate of 12%, inflation rate of 3%, value-added tax for CBM production of 5%, income tax of 33%, and CBM gate price of 1.20 yuan/m<sup>3</sup>, the results of the project economic evaluation are shown in Table 7. The main affected factors to the evaluation of the project are the total investment, CBM sales price and operating cost. The results of the sensitivity analysis for the variation of each factor are shown in Fig.3.

**Table 7. The results of the economic evaluation of the project**

Item	Index
Total investment	694.68 million yuan
Price at well site	1.20 yuan/m <sup>3</sup>
IRR	18%
NPV	120 million yuan
Pt	12 years

**Fig.3 Sensitivity analysis curve of the CBM surface development**

The results show that this project would have better profitable capability as well as anti-risk

capability. At the same time, the variation of CBM sales price would have the largest influence on the economic results of the project.

#### **5.4 The benefit of energy saving and environment protection**

The project will replace coal as city gas with annual capacity of 200 million m<sup>3</sup>, according heat value, which can replace standard coal 1.064 million ton. In Yangquan mining area, the sale coal heat value, sulphur and ash content is 6500kcal/kg, 0.8% and 10% respectively. Thus, the implement of the project can reduce fly ash 2.06t、slag 97,000t and SO<sub>2</sub> 15,000t.

As to CO<sub>2</sub> emissions reduction from the project, the combustion of CBM 200 million m<sup>3</sup> would emit CO<sub>2</sub> 368,000t; in contrast, consuming 1.064 million ton standard coal will emit CO<sub>2</sub> 2.83 million ton. In total, the execution of the project can reduce CO<sub>2</sub> emission 2.462 million ton.

#### **5.5 The major barriers to the project execution**

##### *1 ) Lack of the success demonstration project*

Recent years, there are high enthusiasms on CBM development with surface wells in China. But due to the economic and technical reasons, there is no success model.

##### *2 ) Lack of fund*

Recent years, due to the weakened coal market, the operating benefit of YCG is affected in certain measure. YCG could not solely undertake this investment and is urgent need for introducing certain outer fund involved.

#### **5.6 The project requirements and existing conditions**

The project needs foreign investors to be involved. The total investments reach 694.68 million yuan, of which exploration cost 4.38 million yuan will be provide by foreign company in the form of venture exploration. Other investment source and proportion are to be determined by discuss.

The exist conditions for the project implementation are as follows:

- 1) Rich CBM resources in Yangquan mining area and good development conditions.
- 2) Taiyuan City government lays stress on the city gas, therefore market is ensured.
- 3) YCG is able to provide 35% of the total investment as well as necessary technicians.

#### **5.7 Risk analysis**

The risk of the project is from two sides, market and technology. The reliability and suitability of CBM surface development technology will direct affect the economic results. In the market side, it is very important to the project profitable whether the user contract can be signed or not before the project initiated.

### **6. The Extension of Underground CMM Recovery Project**

#### **6.1 Project overview**

This project is to take underground CMM development as a sector. The production scale of the project is 60 million m<sup>3</sup>/a and all the gas production will be provide to Yangquan City

using as town gas. At present, YCG underground CMM recovery is mainly to solve the mine safety, with low recovery rate as 25%. The extension of underground CMM recovery project is not only increased the recovered CMM, but also increase the coal productivity. It has the characteristic of less investment, fast step and better effect. Therefore, YCG planned four means to increase the CMM recovery to gain more profit.

1. To input more surface and underground equipment, to fully bring the CMM potential into play in coalmine No.5.
2. To adjust the mining method and series in coal mine No.1-3, Xinjing, and input more in the seam 12 and adjacent seams to increase the CMM recovery.
3. To increase the gob CMM recovery rate from 10% to 15% of the total.
4. To test the abandoned mine CMM drainage. The comparative study shows that the abandoned mine methane drainage in Yangquan mining area will increase CMM recovered greatly.

It is predicted that with above-mentioned four sides work done, the recovered CMM will be over 30% of the total, and the recovered CMM will increase 60 million m<sup>3</sup>/a. If the investment is available, some work can be completed in 1- 2 years. YCG propose to start the project in 2002.

## 6.2 Financial analysis

The total investment of the project is 90 million yuan. The 65% of total investment is planned to be introduced from outside investment and fund sources. The other 35% of the investment will be supplied by YCG as equity. The project may gain 60 million m<sup>3</sup> more CMM annually. It is calculated as stable 20 years production with CMM price of 0.6 yuan, the product value will be 480 million yuan.

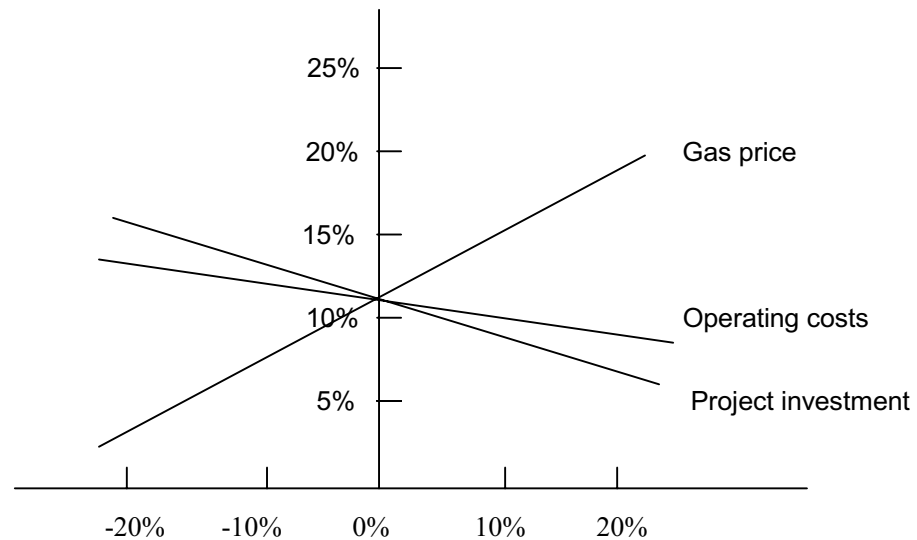
Based upon the other coal enterprise experience, the underground CMM operational cost is 0.3 yuan. Normally, the annual sell income is 36 million yuan, the operating cost 18 million yuan, among which 4.5 million yuan depreciation, therefore the project annual benefit is 18 million yuan.

Discounted cash flow methods are used to analyze the capability for profitability of the CMM project. The basic financial assumptions include a real discount rate of 12% and inflation factor of 3%. After the project is put into operation, the income tax rate will be 0 for the first 5 years, after which the income tax rate is 33%. The major technical and economic index is calculated and shown in Table 8. The main affected factors to the evaluation of the project may be the total investment, CMM sales price and operating cost. Results of the sensitivity analysis for the variation of each factor are shown in Fig.4.

**Table 8. The major technical and economic index of the CMM extension project**

Item	Index
Total investment	90 million yuan
Output capacity	60 million m <sup>3</sup> /a
CMM sale price	0.6 yuan/m <sup>3</sup>
IRR	12%
NPV	32 million yuan
Pt	10 years





**Fig.4 Sensitivity analysis curve of the CMM project**

The financial analysis results show that this project has certain profitable ability. The sensitivity analysis shows that the variation of the CMM sales price would have the largest influence on the economic results of the CMM project.

### 6.3 The benefit of energy saving and environment protection

The project will replace coal as city gas. It is calculated according heat value, the project will recover 60 million m<sup>3</sup> more methane, which can replace standard coal 320,000 ton. In Yangquan mining area, the sale coal heat value, sulphur and ash content is 6500kcal/kg, 0.8% and 10% respectively. Thus, the implementation of the project can reduce fly ash 0.62t, slag 29,000t and SO<sub>2</sub> 0.45t.

The project recovers 60 million m<sup>3</sup> (42,700t) of CMM emissions annually, which is equivalent to emissions reduction of 896,000 t/ CO<sub>2</sub>. In addition, the project will burn 60 million m<sup>3</sup> of CMM, to emit 110,400t CO<sub>2</sub>; in contrast, consuming 32,000t standard coal would emit CO<sub>2</sub> 850,000t. Therefore, the execution of the project can reduce CO<sub>2</sub> emission 1636,300t.

### 6.4 The major barriers to the project execution

#### 1 ) Lack of the success demonstration project

Due to the economy and technical reasons, there always takes CMM development as a mine safety means. There isn't commercial operation success model, so that there is certain risk for investing in this project.

#### 2 ) Lack of fund

Recent years, due to the weakened coal market, the operating benefit of YCG is affected in certain measure. The extension of underground CMM recovery project needs investment 90 million yuan initially. Therefore, YCG could not solely undertake this investment.

### 6.5 The project requirements and existing conditions

This project requires investor and technology providers. Investors are required to input 90 million yuan, which can be invested in the form of equipment lease. The technology provider

need provide the advanced underground drainage equipment, or mature gob/abandoned mine methane drainage method.

The exist conditions for the project implementation are as follows:

- 1) YCG is able to provide 35% of the total investment as well as necessary technicians.
- 2) Yangquan City government lays stress on the city gas, therefore market is ensured.
- 3) YCG has rich underground CMM drainage experience, which may provide all means of convenient conditions for the project execution.

## 6.6 Risk analysis

The risk of the project is from two sides, market and management. In the market side, it is very important to the project profitable whether the CMM price is ensured. In the management side, it is extremely important whether the YCG will actively co-operate and provide convenient conditions.

## 7. CMM Power Generation Project

### 7.1 Project overview

There are three self installed coal fired power plant, with remained annual capacity of  $5 \times 10^8$  kWh, and in recent years, the power consumed by YCG is above  $8 \times 10^8$  kWh. Based the development scheme, in future 10 years, the power consumed by YCG will increase with annual average 11%. There is much lack between supply and demand.

Since the market of CMM using as city gas is saturated, and YCG is lack of electricity, it is decided to utilize part of captured CMM for power generation. It means to take the CMM drained from coal mine No. 1, 2 and 4 to supply city gas system, and take the CMM captured from mine No.3 and Xinjing for power generation.

At present, the CMM captured from mine No.3 and Xinjing is about 32 million  $\text{m}^3$ . If it is fully used for power generation, considering 5% leaking, the CMM can be used for power generation is 30.40 million  $\text{m}^3$ . According to calculation, the methane from those mines can assist an 11 kW CMM power plant. The major technical and economic index of CMM power plant is shown in table 9.

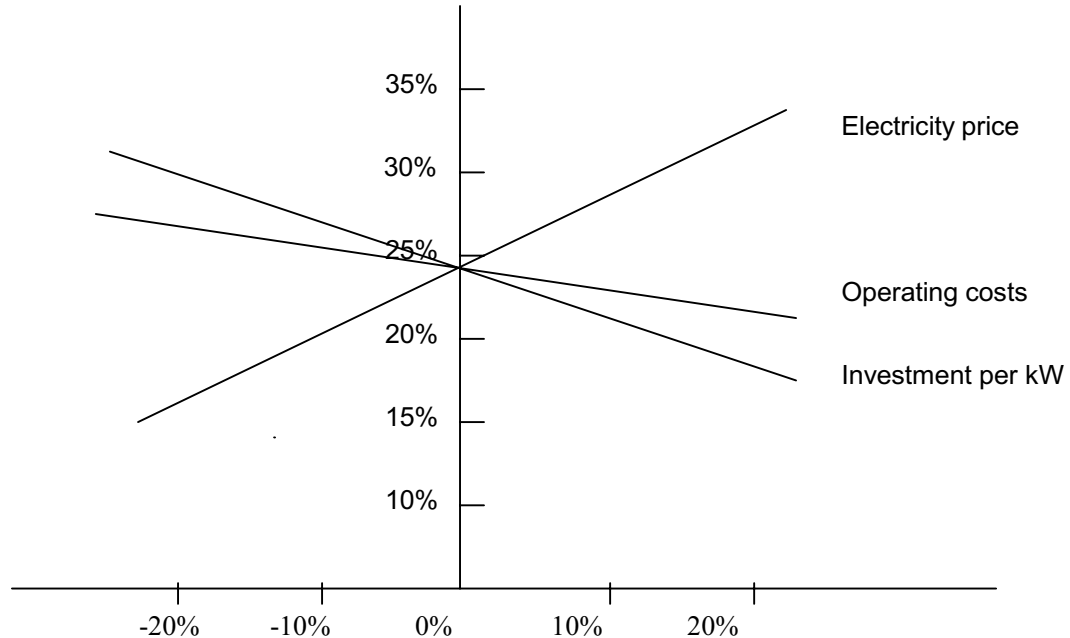
**Table 9. The major technical and economic index of the CMM power plant**

Item	Unit	Quantity	Remarks
Installed capacity	MW	11	
Power generated	$10^6$ kWh/a	79.20	Yearly operating 7200 hours
Power can be supplied	$10^6$ kWh/a	73.26	Exclude self-consumed 6% and
CMM consumed	$10^6$ $\text{m}^3$ /a	23.76	line loss 1.5%
Standard gas consumption	$\text{m}^3$ /kWh	0.3	Pure methane
Construction period	year	1	
Total investment	million yuan	64.60	
Investment per unit	yuan /kW	5,873	

The CMM power plant is planned to build near Xinjing mine, where the CMM source is close and power grid fly over. If the investment available, it is possible to be completed within a year. The service life is over 10 years.

## 7.2 Financial analysis

The total investment of the project is 64.6 million yuan, of which the 35% will be provide by YCG as equity. The other 65% (41.99 million yuan) of total investment is planned to be introduced from banks, foreign companies and overseas financial organizations. The loan interest should be lower than 6.5%.



**Fig.5 Sensitivity analysis curve of the CMM power generation**

Discounted cash flow methods are used to analyze the capability for profitability of the CMM project. The basic financial assumptions include a real discount rate of 12% and inflation factor of 3%. After the project is put into operation, the income tax rate in first 5 years is free, then 33%. The electricity price is 0.28 yuan/kWh, the power generation cost is 0.20 yuan/kWh, and the CMM price is 0.3 yuan/m<sup>3</sup>. The results of the preliminary economic evaluation for the CMM power plant are shown in Table 10.

The sensitivity analysis of the project is based on the investment per kW, power price on sale and operation cost (Fig.5). The results indicate that this project would be highly profitable. The electricity price variation is the factor that affects profitability the most.

**Table 10. The major economy index of the CMM power generation project**

Item	Index
CMM price	0.3 yuan/m <sup>3</sup>
Electricity price	0.28 yuan/kWh
Methane consumption	23.76 million m <sup>3</sup> /a
IRR	23%
NPV	14.95 million yuan
Pt	7 years

## 7.3 The benefit of energy saving and environment protection

When put into operation, the power plant will consume 23.76 Mm<sup>3</sup> of CMM annually. Currently, YCG's coal fired power plant has a heat rate of 0.373 kg/kWh, therefore the CMM power plant can save 29,500 t of coal per year. In Yangquan mining area, the sale coal heat value, sulphur and ash content is 6500kcal/kg, 0.8% and 10% respectively. As a result,

power generation using CMM can correspondingly reduce fly ash 24.5t, slag 817.5t and SO<sub>2</sub> 418t.

The project can reduce CMM emission 23.76 million m<sup>3</sup> (16,900t), which is equivalent of reducing CO<sub>2</sub> emission 354,900 t. As to the CO<sub>2</sub> reduction of the whole project, it burns CMM 23.76 million m<sup>3</sup>, to emit CO<sub>2</sub> 436,000 t; in contrast, consuming 29,500t standard coal will emit CO<sub>2</sub> 78,400 t. In total, the execution of the project can reduce CO<sub>2</sub> emission 390,000 t.

#### **7.4 The major barriers to the project execution**

##### *1) Lack of Technologies*

The capacity of domestically produced gas engines for power generation is small and reliability is poor. It is necessary to introduce advanced power generation equipment from abroad, and have training for the staff of the power plant.

##### *2) Lack of Funds*

The investment of 75 million yuan is needed for the project. It is difficult for YCG to fund this amount without outside financing.

#### **7.5 The project requirements and exist conditions**

This project requires investors and technology providers as partner. Technology providers should provide complete sets of gas fired generation equipment and training for personnel. Investors are required to input 41.99 million yuan, which can be invested in the form of leasing the equipment.

The exist conditions of the project are as follows:

- 1) YCG is capable to provide 35% of the total investment, as well as necessary technicians.
- 2) The quality and quantity of CMM is ensured to supply.
- 3) YCG is a big power consumer. So the electricity can be consumed within YCG.

#### **7.6 Risk analysis**

The risk of the project is from two sides, technology and market. The reliability of equipment and suitability will directly affect the CMM power plant operation. In the market side, it is very seriously affect the project profitable that the variation of CMM price and electricity price.

### **8. Conclusions and Suggestions**

- (1) There is rich CBM resources in Yangquan mining area, with less than 1500m. The CBM resource is 687.4 billion m<sup>3</sup>. There are multiple seams with certain thickness, which deposit shallow with high gas content, good reservoir condition.
- (2) YCG is one of Chinese largest 520 industrial companies, and has achieved profit for 8 years. Which sufficient fund, high bank credit and rich human resource, the enterprise is capable to manage CBM/CMM development and utilization project.



- (3) There is certain base of CMM drainage and wide utilization market. At present, the annual CMM recovery is around 120 million m<sup>3</sup>. There is much lack between supply and demand of electricity in YCG and in adjacent cities, there is CBM supply lack. So there is no market problem for CBM/CMM recovered.
- (4) Based upon the CBM/CMM potential and market conditions, the CMM recovered can be provided to Yangquan City using as town gas. The CBM developed from surface well in Shouyang area can be supplied to Taiyuan.
- (5) The CBM/CMM development and utilization projects may adopt the pattern of product share contract, co-operation, or equipment lease. The fund source can be banks, foreign investors and overseas financial organizations.
- (6) At present, the major barriers of these projects in Yangquan mining area are lack of funds, technologies and the irrational management. The risks of these projects are the suitability of new technique and the variation of the CBM/CMM price.

In order to speed up the development of the CMM industry in the Panjiang mining area, suggestions are made as follows:

- (1) To actively introduce foreign funds and technologies to quicken the execution of the CBM/CMM projects. To combine the coal production with CMM development, and fully utilize the government and enterprise fund source to development the CBM/CMM resources in Yangquan mining area.
- (2) To reorganize specialized CBM/CMM development organization, which take all kind of CBM/CMM development and utilization project, fully mobilize the existing inner source; actively promote the CBM/CMM development utilization.
- (3) The CBM/CMM market development should follow the principle of from small to large, from near to remote. The extension of underground CMM recovery project should aim at local market. The CBM surface development project should consider the gas supply to adjacent cities.

## **China Coalbed Methane Clearinghouse**

China Coalbed Methane Clearinghouse (CBMC), which is funded jointly by the former Ministry of Coal Industry, PRC and the US Environmental Protection Agency, was established in August 1994. The Clearinghouse is part of the China Coal Information Institute. The goal of the Clearinghouse is to promote the development of coalbed methane recovery and use projects in China.

The Clearinghouse undertakes a variety of activities, including:

- Providing consulting services to developers, including financial, market, and economic analyses of potential coalbed methane projects;
- Creating a domestic industry network for information exchange and project development and connecting potential developers with these contacts;
- Providing logistic support to representative of foreign organizations visiting China;
- Organizing conferences, workshops and technical seminars;
- Researching and publishing technical documents, including journals and reports;
- Recommending policies on coalbed methane recovery and use to government agencies.

With regard to the US EPA sponsored project Coal Mine Methane Market Development, the Clearinghouse prepares data packages of coal mine methane projects in 8 key mining areas, including Panjiang, Jincheng, Huainan, Huaibei, Fushun, Yangquan, Pingdingshan and Jiaozuo, and disseminates these data packages to interested investors and developers for international technical and economic cooperation in CMM projects. This data package of Panjiang is prepared by Mr. Huang Shengchu, Mr. Xu Huijun, Mr. Zhu Chao and Ms. Liu Xin of the the CBMC, Mr. Bai Wunxiang, Mr. He Suli and Mr. Liu Zilion of the Yangquan Coal Group Co., Ltd. and reviewed by Mr. Karl Schultz of US EPA and Mr. Li Baoyu of the Yangquan Coal Group Co., Ltd. The Clearinghouse also acknowledges the input from the Raven Ridge Resources Inc.



Mr. Edu Hassing (middle) from Asian Development Bank and Mr. Charles Johnson (fourth from left) from West-East Center work together with specialists from Yangquan Coal Group Co., Ltd. and the Clearinghouse in field.

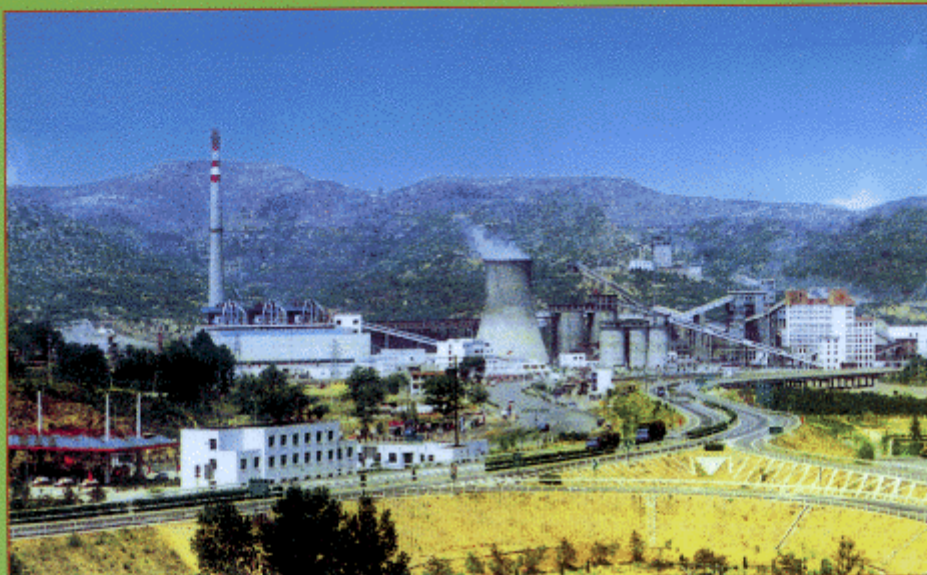


Six gas holders have been built in Yangquan mining area, with total storage capacity of 160,000 m<sup>3</sup>.



Eight surface gas drainage stations have been constructed, with total drainage about 120million m<sup>3</sup>/a.





Overview of Yangquan Mining Area

Yangquan Mining Group Co., Ltd.  
No. 5, West of Beida Street  
Yangquan city  
Shanxi 045000, China  
Tel/Fax: 0086-353-7070897  
Email: ycgcbm@public.yq.sx.cn

China Coalbed Methane Clearinghouse  
35 Shaoyaoju, Chaoyang District  
Beijing 100029, China  
Tel/Fax: 0086-10-84610779  
Email: cbmc@public.bta.net.cn  
Website: <http://www.coalinfo.net.cn>